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# APPLICATION FOR LETTERS PATENT

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**Thin Profile Battery Bonding Method, Method Of Conductively Interconnecting Electronic Components, Battery Powerable Apparatus, Radio Frequency Communication Device, And Electric Circuit**

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## TECHNICAL FIELD

## **BACKGROUND OF THE INVENTION**

One mechanism by which thin profile batteries are electrically connected with other circuits or components is with electrically conductive adhesive, such as epoxy. Yet in some applications, a suitably conductive bond or interconnection is not created in spite of the highly conductive nature of the conductive epoxy, the outer battery surface, and the substrate surface to which the battery is being connected. This invention arose out of concerns associated with providing improved conductive adhesive interconnections between thin profile batteries and

conductive nodes formed on substrate surfaces. The invention has other applicability as will be appreciated by the artisan, with the invention only being limited by the accompanying claims appropriately interpreted in accordance with the Doctrine of Equivalents.

## SUMMARY OF THE INVENTION

The invention in one aspect includes a thin profile battery bonding method. In one implementation, a curable adhesive composition is provided which comprises an epoxy terminated silane. A thin profile battery and a substrate to which the thin profile battery is to be conductively connected are also provided, The curable adhesive composition is interposed between the thin profile battery and the substrate. It is cured into an electrically conductive bond electrically interconnecting the battery and the substrate.

The invention in another aspect includes a method of conductively interconnecting electronic components. In one implementation, a curable adhesive composition comprising an epoxy terminated silane is provided. First and second electronic components to be conductively connected with one another are provided. The curable adhesive composition is interposed between the first and second electronic components. The adhesive is cured into an electrically conductive bond electrically interconnecting the first and second components.

The invention in still another aspect includes interposing a curable epoxy composition between first and second electrically conductive

components to be electrically interconnected. At least one of the components comprises a metal surface with which the curable epoxy is to electrically connect. The epoxy is cured into an electrically conductive bond electrically interconnecting the first and second components. The epoxy has an effective metal surface wetting concentration of silane to form a cured electrical interconnection having a contact resistance through said metal surface of less than or equal to about 0.3 ohm-cm<sup>2</sup>.

The invention in a further aspect includes a battery powerable apparatus. In one implementation, such includes a substrate having a surface comprising at least one node location. A thin profile battery is mounted over the substrate and node location. A conductive adhesive mass electrically interconnects the thin profile battery with the node location, with the conductive adhesive mass comprising an epoxy terminated silane.

The invention in still a further aspect includes a radio frequency communication device. In one implementation, such includes a substrate having conductive paths including an antenna. At least one integrated circuit chip is mounted to the substrate and in electrical connection with a first portion of the substrate conductive paths. A thin profile battery is conductively bonded with a second portion of the substrate conductive paths by a conductive adhesive mass, with the conductive adhesive mass comprising an epoxy terminated silane.





One example 3-glycidoxypropyltrimethoxysilane is available from Dow Corning Corporation of Midland, Michigan, as Z-6040<sup>TM</sup> Silane. An example resin and hardener system for a conductive epoxy is available from Creative Materials, Inc., of Tyngsboro, MA, as Part Nos. CMI 116-37A<sup>TM</sup> and CMIB-187<sup>TM</sup>, respectively. In a preferred example, from 0.5 to 2.0 weight parts of Z-6040<sup>TM</sup> silane is combined with 100 weight parts of the CMI 116-37A<sup>TM</sup> silver epoxy resin. A preferred concentration of the Z-6040<sup>TM</sup> is 1 weight part with 100 weight parts of epoxy resin. Such a solution is thoroughly mixed and combined with, for example, 3 weight parts of the CMIB-187<sup>TM</sup> hardener, with the resultant mixture being further suitably mixed to form composition 26.

The composition is applied to one or both of battery 10 or substrate 22, and provided as shown in Fig. 3. An example size for conductive mass 26 is a substantially circular dot having a diameter of about 0.080 inch (0.2032 cm) and a thickness of about 0.002 inch (0.00508 cm). Resistance of a fully cured mass 26 was measured with an ohmmeter from the top of the mass to the substrate surface, which comprised a nickel-clad stainless steel Eveready CR2016<sup>TM</sup> button-type battery can. Typical measured resistance where no epoxy-terminated silane or other additive was utilized ranged from 10 ohms to 100 ohms, with in some instances resistance being as high as 1000 ohms. These correspond to respective calculated contact resistances ranging from about 0.32 ohm-cm<sup>2</sup> to 3.24 ohms-cm<sup>2</sup>, with as high as 32.43 ohms-cm<sup>2</sup>,

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1 when ignoring the volume resistances of the epoxy mass and substrate.  
2 At the time of preparation of this document, 10 ohms (and its  
3 associated calculated contact resistance of  $0.32 \text{ ohm-cm}^2$ ) is considered  
4 high and unacceptable for purposes and applications of the assignee,  
5 such as will be described with reference to Fig. 4. Yet where the  
6 epoxy-terminated silane was added, for example at a weight percent of  
7 2% or less, the typical resistance value and range dropped significantly  
8 to 0.1 ohm to 1.0 ohm, with 0.2 ohm being typical. These correspond  
9 to respective contact resistances of about  $0.0032 \text{ ohm-cm}^2$ ,  $0.032$   
10  $\text{ohm-cm}^2$ , and  $0.0064 \text{ ohm-cm}^2$ .

11 It is perceived that the prior art conductive bonding without the  
12 epoxy-terminated silane results from poor wetting characteristics of the  
13 conductive epoxy with the metal outer surface of the button-type  
14 battery, which typically comprises a nickel-clad stainless steel. The  
15 epoxy-terminated silane significantly improves the wetting characteristics  
16 relative to the metal surfaces, such as nickel-clad stainless steel, in a  
17 conductive epoxy system in a manner which is not understood to have  
18 been reported or known in the prior art. Accordingly in accordance  
19 with another aspect of the invention, a thin-profile battery bonding  
20 method interposes epoxy between a battery and substrate with at least  
21 one of such having a metal surface to which the curable epoxy is to  
22 electrically connect. The epoxy has an effective metal surface wetting  
23 concentration of silane to form a cured electrical interconnection having  
24 a contact resistance through said metal surface of less than or equal to



about 0.30 ohm-cm<sup>2</sup>. More preferred, the epoxy has an effective metal surface wetting concentration of silane to form a cured electrical interconnection have a contact resistance through said metal surface of less than or equal to about 0.16 ohm-cm<sup>2</sup>. Most preferred, such concentration provides a contact resistance of less than or equal to about 0.032 ohm-cm<sup>2</sup>.

The curable adhesive composition is then cured into an electrically conductive bond which electrically interconnects the battery and substrate as shown in Fig. 3. In the preferred embodiment, such electrically conductive bond also is the sole physical support and connection of the battery and its terminals relative to substrate 22.

Although the invention was reduced to practice utilizing formation of a conductive interconnection between a metal battery terminal and a printed thick film on a substrate, the invention has applicability in methods and constructions of producing an electric circuit comprising other first and second electric components which electrically connect with one another through a conductive adhesive mass comprising, in a preferred embodiment, an epoxy-terminated silane.

Fig. 3 depicts an exemplary battery powerable apparatus and electric circuit 30 in accordance with an aspect of the invention. In one preferred implementation, battery powerable apparatus 30 preferably comprises a radio frequency communication device 50 as exemplified in Fig. 4. In such example, substrate 22 preferably comprises a flexible circuit substrate, with nodes 25 and 24 constituting a portion of a series



